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The diet of *Microtus pyrenaicus* (De Sélys-Longchamps, 1847) in the western Pyrenees

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Abstract

The diet of *Microtus pyrenaicus* was studied based on the analysis of remains found in 74 stomachs. The most representative type of food in the diet was made up of the aerial vegetative parts of dicotyledons (%N = 59.3). The aerial vegetative parts of monocotyledons also constituted a large part of the diet (%N = 30.0). The remaining food types consisting of flowers, bryophytes, fungi, and seeds of herbaceous plants, contributed 10.7% of the diet (%N). Although the diet was more varied in summer and autumn, the green parts of plants were the greatest source of food throughout the year. Taking into account the surface area occupied by dicotyledon and monocotyledon plants in the meadows, the species makes a positive selection of dicotyledons, favoring these over the monocotyledons. The low values for cumulative diversity and equitability indicate that the species has a stenophagous diet.

Introduction

Microtus pyrenaicus inhabits areas of the Pyrenee Mountains (North Iberian Peninsula). At present little research has been performed on the biology of this species. The data published to date refer to its reproductive cycle (Castién and Gosalbez 1995) and to the characteristics of its habitat (Krapp 1982; Saint-Girons et al. 1978; Gosalbez et al. 1985; Borghi et al. 1994). This is the first study that has been performed the diet of this species.

Material and methods

The study area is located in the Quinto Real Massif (western Pyrenees). The dominant vegetation in this area is an acidophilic *Fagus sylvatica* forest which is in association with *Saxifrago hirsutae-Fagetum sylvaticae* (Braun-Blanquet 1967). Samples were caught mostly in small natural meadows located amid the forest at altitudes ranging between 650 m and 750 m. The average annual precipitation is about 2,138 mm, with the highest levels in spring and autumn. The mean temperature is 8.8 °C. The highest average temperature is in August (16.6 °C) and the lowest in January (2.9 °C).

The vegetative cover of the meadows was estimated by randomly throwing a needle into the grass and recording the species that it hit on each throw (Greigh-Smith 1964).

There are several methods to estimate the proportion of diet components (Obrtel and Holisova 1976; Butet 1985). A critical review of some of these can be found in Hansson (1970). The method used here to prepare the stomach samples was that of Ventura et al. (1989). Each stomach content was sub-divided into six equal parts. A sample was then taken from each of these parts and spread out on a glass slide. Each sample was rinsed with Hertwitg liquid (Baumgartner and Martin 1939) and mounted with glycerin. All 6 of the preparations underwent an examination to determine the frequency of appearance of the diet components in 20 different fields, obtained at 100 X under the microscope. Our aim was to select a sample of 10 stomachs per quarter year in order to determine the diet variation over the two-year study period. We also attempted to balance the presence of males and females. The identification of the remains was carried out by comparing a collection of microscopic preparations of plant epidermis.

Analysis of trophic diversity was done according to Ruiz (1985), who has developed methods based on the models of Hurtubia and Di Castri (1972), Hurtubia (1973) and Pielou (1966 a, b, 1975).

A matrix was prepared according to this method. Rows represented different types of food, and columns, the distinct variables: appearance frequency in number (N) and percentage (%N), percentage of stomachs with a specific type of food (%P) and Simpson's dominance ratio ($D = \Sigma Pi^2$)($1 < i < z$, z = total number of digestive tracts). Pi is the probability of a food unit from stomach i belonging to a certain type of food. $D' = D/z \times 100$ compares the different matrix indices. $D'' = D'/\Sigma D' \times 100$ expresses the value of D′ as a percentage. The cumulative diversity curve Hz was drawn by arranging the stomachs according to their diversity in increasing or decreasing order. This was used to estimate the representativity of the sample studied. To calculate the diversity of the diet the Brillouin expression was used: $H = 1/N \times (\log_2 N! - \Sigma \log_2 N_i!)$. Brillouin's diversity index is recommended for the investigation of trophic diversity by various authors (Pielou 1966 a, b, 1975; Hurtubia 1973; Ruiz 1985). The value of Hz corresponded to the last value of the cumulative diversity function. $Hp = 1/(z - t) \Sigma hk$, ($t + 1 < k < z$). $hk = (Mk \times Hk - Mk\text{-}1 \times Hk\text{-}1)/(Mk - Mk\text{-}1)$, Mk = number of prey of the k digestive tract, Hk = diversity of the k digestive tract, t = point at which Hk/k curve becomes stabilized. The average diversity values $\bar{H}$ and the equitability (E) were also compared.

The similarity between the diets of each season was estimated using Spearman's correlation coefficient. The diet of males and females was compared by means of the Kolmogorov-Smirnov and Spearman's correlation coefficient considering its greater proximity. The Chi-squared test was used to compare the green diet with its availability in the field.

The diet of *Microtus pyrenaicus* was studied using the analysis of 74 stomachs from individuals caught over a two year period of field work. This made it possible to identify a total of 4,881 particles belonging to 11 different food types.

Results

Diet composition

Figure 1 shows the cumulative diversity curves in which the stomachs are arranged according to their diversity in increasing or decreasing order. In the top curve, based on the

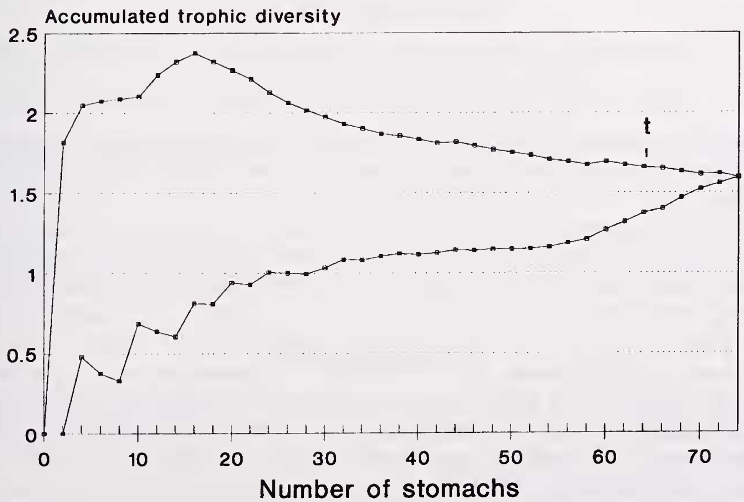

Fig. 1. Cumulative trophic diversity with stomachs arranged according to their diversity in increasing and decreasing order. Point t represents the tract from which the curve is considered stabilized (n = 74).

Table 1. Trophic matrix for the annual diet of *Microtus pyrenaicus* (n = 74).

	N	%N	P	D	D′	D″
Arthropods						
Adults	8	0.2	10.8	0.003	0.006	0.006
Lichens	274	0.5	1.3	0.34	0.46	0.73
Fungi	95	1.9	10.8	0.61	0.82	1.29
Mosses	30	0.6	12.2	0.04	0.06	0.09
A. v. p. Dicotiled.	2896	59.3	95.9	33.18	44.84	70.19
A. v. p. Monocotil.	1463	30.0	82.4	9.95	13.44	21.04
Floral parts	180	3.7	16.2	2.31	3.12	4.89
Pulpous fruits	39	0.8	2.7	0.24	0.32	0.51
Seed grasses	40	0.8	12.2	0.05	0.07	0.12
Seeds of *Fagus*	30	0.6	1.3	0.29	0.39	0.61
Roots	73	1.5	4.0	0.25	0.34	0.53

Table 2. Taxonomic groups of plants identified in the seasonal diet of *Microtus pyrenaicus.*

Autumn	Winter	Spring	Summer
Jasione montana	*Achillea millefolium*	*Stachys sylvatica*	*Prunella vulgaris*
Bellis perennis	*Potentilla erecta*	*Lamiastrum galeobdolon*	*Potentilla sterilis*
Hypochoeris radicata	*Potentilla* sp.	*Ranunculus nemorosus*	*Plantago* sp.
Lamium maculatum	*Lamiastrum galeobdolon*	*Ajuga reptans*	*Trifolium pratense*
Prunella vulgaris	*Ranunculus* sp.	*Ajuga* sp.	*Trifolium repens*
Ranunculus repens	*Plantago* sp.	*Stachys sylvatica*	*Trifolium reptans*
Stellaria uliginosa	*Trifolium* sp.	*Prunella vulgaris*	*Trifolium* sp.
Plantago lanceolata	Gramineae	*Plantago lanceolata*	Gramineae
Plantago sp.	*Anthoxantum odoratum*	*Plantago* sp.	*Carex* sp.
Trifolium reptans	*Carex* sp.	*Trifolium repens*	
Trifolium sp.		*Trifolium pratense*	
Gramineae		*Trifolium* sp.	
Cinosurus cristatus		Gramineae	
Poa pratensis			
Carex sp.			

accumulation of 62 stomachs, the graph is deemed to be sufficiently stabilized so as to consider that the sample is an accurate representation of the diet of the population in the area studied.

The most representative type of food in the diet consists of aerial vegetative parts (A. v. p.) of Dicotyledoneae (Tab. 1). Several species have been identified within this group (Tab. 2). The bulk of the diet is made up of the aerial vegetative parts of the Monocotyledoneae in addition to the above. A number of taxa have been identified in this group (Tab. 2). The remaining food types %N = 10.7 comprise: flowers (Leguminosae, Gen. *Trifolium*, Compositae and Gramineae have been found); bryophytes; fungi (in two stomachs identified as Ascomyceta, Gen. *Emericella*); herbaceous seeds; arthropods (in 3 cases identified as mites); radical parts; fleshy fruits (at least in one case belonging to *Rubus* sp.); *Fagus sylvatica* seeds and a small amount of lichens.

The trophic diversity values obtained in the sample studied are as follows: $\overline{H} = 0.783$ (E. S. = 0.046, n = 74), $H_p = 1.249$ (E. S. = 0.331, n = 12), $H_z = 1.595$, E = 0.445.

Table 3. A comparison of the seasonal diets using Spearman's range correlation test. Above the diagonal: correlation coefficients. Below the diagonal: significance levels.

	Aut. 1984	Win. 1985	Spr. 1985	Sum. 1985	Aut. 1985	Win. 1986	Spr. 1986	Sum. 1986
Aut. 1984		0.647	0.606	0.552	0.631	0.724	0,657	0,254
Win. 1985	0.041		0.783	0.645	0.400	0.447	0,481	0,292
Spr. 1985	0.055	0.013		0.719	0.636	0.499	0,782	0,254
Sum. 1985	0.081	0.041	0.023		0.418	0.356	0,760	0,465
Aut. 1985	0.046	0.206	0.044	0.186		0.599	0,673	0,264
Win. 1986	0.022	0.157	0.115	0.261	0.058		0,532	0,471
Spr. 1986	0.038	0.128	0.013	0.016	0.033	0.092		0,507
Sum. 1986	0.421	0.356	0.421	0.142	0.403	0.136	0,108	

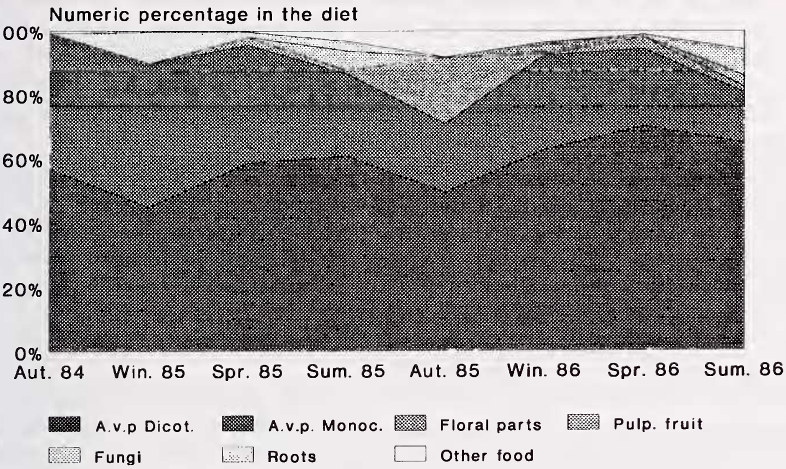

Fig. 2. Seasonal variation in the numerical percentage (N%) of the main types of food.

Seasonal variation in the diet

A comparison of the seasonal diets by means of the correlation index (Tab. 3) shows that the diet remains basically the same except during the two summers and one of the autumn periods (1985) when somewhat more individualized diets were observed. Throughout the two year study, the dicotyledons generally made up the largest proportion of the diet (Fig. 2). The monocotyledons, which appear in smaller percentages, were also a major food source during the study period. Overall, there appears to be a certain pattern in the abundance of green food, which reaches its peak in spring.

In summer and autumn of 1985 and the summer of 1986 the diet expanded to other types of food: fungi, flowers, fruits and seeds of herbaceous plants or beech trees.

Food selection

The green food consumed by *Microtus pyrenaicus* makes up 89.3% of the diet. Most of the green food components consist of dicotyledons (66.4%) and the remainder (33.6%) are monocotyledons. A comparison of the frequencies of these two components in terms of actual inclusion in the diet and the expected frequency based on field availability (53.5% monocotyledons and 46.5% dicotyledons) shows significant differences (Chi-squared = 2111.1, d. f. = 1, $p < 0.001$).

Diet comparison between sexes

Diets of males and females were compared using Spearman's correlation test with the following results: $r_s = 0.560$; $n = 11$; $p = 0.076$. The application of the Kolmogorov-Smirnov test resulted in a maximum estimated distance of DN = 0.182, p = 1.0. The following data refer to niche amplitude for each sex: Males: Number of stomachs studied = 35; Food Types = 9. $\overline{H} = 0.768$ (E. S. = 0.066, n = 35), $H_p = 0.953$ (E. S. = 0.037, n = 10), $H_z = 1.411$, E = 0.447. Females: Number stomachs studied = 39; Food Types = 11. $\overline{H} = 0.769$ (E. S. = 0.065, n = 39), $H_p = 1.537$ (E. S. = 0.322, n = 12), $H_z = 1.673$, E = 0.480.

Discussion

No references to the diet of *Microtus pyrenaicus* were found in the literature. Based on data collected in this study it may be concluded that the diet of this species is fundamentally herbaceous, consisting of the aerial green parts of pratal herbaceous plants, made up mostly of dicotyledons. The amplitude of the surface covered by the two diversity curves implies that there is some variation in the patterns of the trophic composition of the stomach contents which is linked to seasonal changes.

Although the number of food types consumed is relatively broad, the low cumulative diversity and equitability values reveal a diet that is specialized in very few resources. The population diversity value (H_p), which is markedly lower than that of cumulative diversity (H_z), also indicates that very few types of food are consumed with a noticeable predominance of anyone type.

On comparing the vegetative cover of monocotyledons and dicotyledons in the field with the ratio in which they appear in the diet, it is evident that the dicotyledons are chosen as the preferred food over monocotyledons.

Taking into account the annual variations in the diet in terms of the production in the herbaceous stratum (Castién 1994), we may conclude that grass makes up the largest part of the diet during spring, which coincides with the beginning of the vegetative period.

Arthropods are practically non-existent in the stomach. It is highly probable that the specimens that have been identified belong to external parasites of the animal itself.

Thus, it is possible to characterize *Microtus pyrenaicus* as a markedly folivorous species, which feeds primarily on dicotyledons, diversifying its diet during the summer by consuming small amounts of other non-green vegetative foods.

The cumulative diversity values and population diversity are slightly higher in females than in males. However, the standard deviation amplitude in the case of H_p does not allow to establish differences at the level of significance.

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Zusammenfassung

Die Nahrung von Microtus pyrenaicus De Sélys-Longchamps, 1847 in den Westpyrenäen

Es wird über die Zusammensetzung der Nahrung von *Microtus pyrenaicus* nach Analysen von Mageninhalten berichtet. Ingesamt wurden 74 Mägen untersucht. Der Speisezettel der Art besteht in erster Linie aus oberirdischen vegetativen Teilen, sowohl von Dikotyledonen (59,3%) als auch von Monokotyledonen (30,0%). Blütenteile, Moose, Pilzen und Kräutersamen bilden den restlichen Anteil

(10%). Das ganze Jahr über ernährt sich die Art vorwiegend von grünen Pflanzenteilen, jedoch läßt sich im Sommer und Herbst eine größere Variation in der Zusammensetzung der Nahrung erkennen. Auf den Wiesen, die sie bewohnt, zieht *Microtus pyrenaicus* die Plätze mit Dikotyledonen-Bewuchs denen mit Monokotyledonen-Bewuchs vor. Aus den vorliegenden (niedrigen) Werten der Gleichmäßigkeit aber auch der kumulativen Diversität der Nahrungzusammensetzung läßt sich schließen, daß die Art stenophag ist.

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